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Advanced Development Active Model: A Users Guide

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ABSTRACT

The Naval Oceanographic and Atmospheric Research Laboratory has developed a numeric model for the prediction of boundary and volume reverberation in shallow-water environments for midfrequency regimes.

The model's theoretic foundation is that of the (Naval Research Laboratory) Range Dependent Active System Performance Model. While retaining the theoretic foundation of the NRL model, it was necessary to introduce new algorithms for the computation of the acoustic ray trajectories, and the calculation of the elemental scattering areas used in the prediction of boundary reverberation. The changes were required to implement range-dependent bistatic reverberation and to account for the possibility of strong sound speed gradients in the upper regions of the water column.

This technical note serves as a users guide for the Advanced Development Active Model. While the model usually performs without major malfunctions, users should remember that this model is a research and development model.

ACKNOWLEDGMENTS

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Advanced Development Active Model: A Users Guide

1.0 INTRODUCTION

The purpose of this technical note is to provide a users manual for the Advanced Development Active Model (ADAM). The ADAM model does not consist of a single module called ADAM or even an umbrella function that ties together a series of programs. It is a collection of programs that can be run in certain sequences to obtain reverberation and target echo levels. It is not a system model, and it makes no claims toward being either user friendly or algorithmically error free. Part of the design criteria was flexibility. With flexibility comes the ability to create predictions that are most kindly described as garbled; thus, any user is cautioned to use care in running and interpreting the output of this model.

1.1 Background

The history of ADAM can be traced to the (Naval Research Laboratory's) Range Dependent Active System Performance Model (RASP). The RASP model was designed to operate in a low- to medium- frequency range for medium- to long-range boundary reverberation prediction (Franchi et al., 1984). When the need arose to predict reverberation envelopes in shallow-water environments, it became apparent that the model would perform well under certain environment conditions. Investigation of the requirements necessary to make reasonable predictions in shallow-water environments lead to the following observations: (1) it is necessary to obtain an appropriate estimate of the bottom loss in the area, and (2) the sound speed profile needed to be fitted with extreme care. In particular, it was necessary to fit the sound speed environment such that areas of high vertical gradients in the sound speed structure did not lead to false minima and/or maxima.

Bottom-loss estimates proved to be available in two forms, either as a Navy standard model or as a geoacoustic model. For the first form there are various algorithms available to make the appropriate transform to bottom loss versus grazing angle as a function of province. The intent of dealing with higher frequencies lead to the inclusion of the High Frequency Bottom Loss (HFBL) curves in the model. The second approach required the ability to create a bottom-loss table and the ability to read that table.

Experimentation with curve fitting algorithms lead to the conclusion that a cubic spline under tension (Cline, 1974) would offer the best solution to the false minima/maxima problem. A new ray-tracing algorithm was constructed with the cubic spline under tension embedded into it. In order to curtail unnecessary reinvention, the output of the new ray tracer was made to conform to the output of the RASP ray tracer. This allowed for the use of the RASP transmission loss estimation algorithms, suitable modified for higher frequencies. Concurrently with these modifications, a new reverberation algorithm was implemented to allow for range dependent bistatic geometries.

1.2 Overview

This manual is organized such that the next major section will list and explain the inputs of each of the primary programs that make up the ADAM model. The third major section will discuss the run streams that are required for the major types of geometries that have been requested. The final section is a summary of this manual. Following the summary there are three appendices that explain the use of secondary programs that are included with ADAM and the structure of input files.

2.0 PROGRAMS

The programs that constitute the ADAM model will be described in this section. The five individual programs that make up ADAM are

- | | | |
|-----|--------|---|
| (1) | TRACE | ray-tracing program |
| (2) | RTHETA | transmission loss estimation program |
| (3) | ARRGRD | arrival structure gridding program |
| (4) | REV | reverberation prediction program
or
NREV
target echo level prediction program. |
| (5) | TGT | range dependent bistatic reverberation file |

The five (The user has the option of using either REV for range independent bistatic cases or NREV for range dependent bistatic cases with the same type and number of inputs; thus, it is considered as a single program.) programs are run in a specific sequence in order to obtain reverberation envelope versus time and maximum target echo level envelope as a function of

range. In this section the inputs that are needed for a successful execution are listed in tabular form with explanation where necessary.

2.1 Program TRACE

TRACE is a ray-tracing program. TRACE uses a single sound speed profile, a single bottom-loss specification, and range-dependent bathymetry along a radial. TRACE launches a set of acoustic rays from a specified sensor depth. As the rays are propagated they cross target (or volume) depths and are reflected from the wave-guide boundaries. At each location where the rays interact with a specified depth or boundary the statistics of the crossing are collected. The statistics collected are those required for active modeling, that is the arc length, travel time, grazing angle, amount of interface loss, and the range at each interaction location.

Table 1 lists the inputs in the order that they appear with a summary explanation. A feature that requires further explanation is glossed over in the first entry. It is possible to specify multiple radial ray tracing; virtually an unlimited number can be specified. But for each radial specified, you are required to re-enter all the information. That is, file names, types of losses, frequencies, ranges, etc. The need for repetitive input of information negates some (if not all) of the positive features of doing multiple radials; it was instituted to allow multiple radials from a single location (hence the specification of position) to be computed for a given sensor at a single pass. The procedure for accomplishing this task is specified in Appendix C. If your need is for a single radial model, the multiple radials feature is worthless.

TRACE produces binary files that read by the program RTHETA. There is no ASCII output or plot capability. This is a design feature. Typical plot capability requires a specific software (or potentially hardware) product for support. ASCII output generates large quantities of material that are seldom used.

Table 1. Inputs for program TRACE and summary explanation.

Enter the number of files to process and the latitude and longitude of the sensor.	*
Enter bathymetric file name.	* File containing bottom depth as a function of range. File name must not exceed 30 characters in length.
Enter range units associated with the bathymetric file: 0 = kilometers, 1 = nautical miles, 2 = kiloyards (value out of range = km).	* Three units for range are supported for input, kilometers, nautical miles, and kiloyards.

Enter depth units associated with the bathymetric file: 0 = meters, 1 = feet, 2 = yards, 3 = fathoms (value out of range = meters).	* Four units of bathymetric depth are supported for input: meters, feet, yards, and fathoms.
Enter sound speed file name.	* File containing sound speed profile; File name must not exceed 30 characters.
Enter depth units associated with the sound speed file: 0 = meters, 1 = feet 2 = yards , 3 = fathoms (value out of range = meters).	* Three units for range are supported for input, kilometers, nautical miles, and kiloyards.
Enter speed units associated with the sound speed file: 0 = meters per second 1 = feet per second. (Default unit (that is, out of range) is m/s.)	* Two units of sound speed are supported for input, meters per second, and feet per second.
Select the source of bottom-loss information: 0 = high frequency bottom-loss curves (HFBL) 1 = Fleet numeric bottom-loss curves (FNWC) 2 = user provided tabular input Default value (invalid selection) is HFBL.	* HFBL offers the choice of ten provinces. FNWC offers the choice of three provinces. User defined tabular input requires: (a) the number of grazing angle bottom-loss pairs (maximum 91) (b) a line consists of grazing angle bottom loss (c) the loss at 0° and 90° be specified.
Enter the frequency for bottom-loss calculation in units of Hertz.	* Frequency in hertz, used for bottom loss (FNWC) and surface loss.
Enter the province number (0 through 9).	a HFBL provinces.
Enter the province for FNWC bottom-loss curves. There are three provinces 1, 2, and 3. The out of range value is 1.	b FNWC areas.
Enter bottom loss file name.	c Bottom-loss file for user input as described above.
Input the sensor depth.	* Sensor refers to source (active emitter) or receiver.
Enter the units of sensor depth: 0 = meters, 1 = feet, 2 = fathoms (Out of range default is meters.)	*
Input the volume reverberation depth.	* Note volume reverberation depth may also be used as a target depth.
Enter the units of volume reverberation depth: 0 = meters, 1 = feet, 2 = fathoms (Out of range default is meters.)	*
Input the target depth.	* Note target depth may also be used as a volume reverberation depth.
Enter the units of target depth: 0 = meters, 1 = feet, 2 = fathoms (Out of range default is meters).	*
Enter the wind speed.	* Wind speed is used for surface loss calculations.
Enter the units of wind speed. 0 = meters per second, 1 = knots	*

Enter the maximum range to which any ray is propagated.	* Note, normally specify the maximum range as 20 % more than actually required.
Enter the units of maximum range: 0 = kilometers, 1 = kiloyards, 2 = nautical miles (Out of range default is kilometers.)	*
Enter the name of the output surface file.	* Valid ASCII file name maximum length 30 characters.
Enter the name of the output bottom file.	* Valid ASCII file name maximum length 30 characters.
Enter the name of the output volume depth file.	* Valid ASCII file name maximum length 30 characters.
Enter the name of the output target depth file.	* Valid ASCII file name maximum length 30 characters.

Notes: * denotes a required input, **a** refers to required inputs if HFBL is selected, **b** refers to required inputs if FNWC is selected, **c** refers to required inputs if an input bottom-loss table is selected (refer to Appendix A for input table requirements), **d** refers to required inputs if volume reverberation depth is greater than 0, and **e** refers to required inputs if target depth is greater than 0.

2.2 Program RTHETA

RTHETA is a program that takes the ray statistics collected by program TRACE and calculates the transmission loss based on caustic corrected ray theory. RTHETA, as used in this model, is a derivative of the RTHETA program integral to the NRL RASP model. It has been modified to calculate attenuation as a function of arc length, to account for attenuation for higher frequency regimes (up to 10 kHz), and to eliminate some unwanted features.

As opposed to the trace program, the multiple file feature does not require the specification of the frequency and beam pattern for each input file. Rather, each input is assumed to be generated by the same sensor; thus, all that needs to be specified is the input TRACE file and the corresponding output file.

The output files from program RTHETA are sequential binary files. The files are used by ARRGRD for creation of a gridded arrival structure for the reverberation program. You may use the output of RHTETA (That is, the outputs from this version of RTHETA are compatible with the outputs of the RASP version.) in RASP program TLVSR (TLVSR inputs are described in Appendix B.) to create transmission loss version range estimates.

Table 2. List of inputs to program RTHETA and summary explanation.

Enter the number of files to process and the latitude and longitude of the sensor.	* Latitude and longitude inputs are not used in this program; thus, both may be set to 0.
Enter kfrq, kbp:	* Input frequency in hertz and number of equispaced vertical elements: 0 implies that the user has a beam pattern file to enter, 1 implies an omnidirectional pattern.
Enter the vertical phone spacing of array (wavelengths) and degrees of maximum tilt from horizontal (- is up).	a Assumes kpb equispaced omnidirectional elements, the tilt (steering angle) is positive downwards.
Enter the name of input beam pattern file.	b ASCII file containing beam pattern (in decibels) from -90 to 90 in 1° increments.
Enter the name of the input TRACE file.	* Input file (either surface, bottom, volume, or target) from program TRACE - limited to 30 characters.
Enter the name of the output file.	* Valid unique output file name.

Note: * denotes a required input, a optional, used only when kbp is greater than 0, b is optional, used only when kbp is less than or equal to 0.

2.3 Program ARRGRD

ARRGRD creates a gridded version of the output from a single or multiple RTHETA for processing in REV or in TGT (Surface and bottom interaction files may be used to predict reverberation only while target and volume depth files can be used to predict either volume reverberation or target echo level.). The output of the RTHETA program is based on ray order, that is, the total number of turning points and reflections. While this file could be used to predict reverberation by performing the gridding at execution time, it seems more efficient for small computers and bistatic geometries to grid the transmission loss estimates prior to initiation of the reverberation program.

Table 3. List of inputs to program ARRGRD and summary explanation.

Enter the number of radials to be processed and the latitude and longitude of the radial origin.	Number of radials is the number of radials starting from a single site all of the same class (that is, bottom). Longitude and latitude should be the ones desired for this program.
--	---

Enter the incremental and maximum range.	Both incremental and maximum range are in kilometers. The only restriction is that maximum divided by incremental be less than 6000.
Enter the number of arrivals per range bin. Maximum number equals to 16.	Number of vertical arrivals per range increment; it is recommended that at least eight be used.
Enter the name of the gridded output file.	Limited to 30 characters.
Enter the name of input RTHETA file.	Output from RTHETA (Note: on multiple radial run all input files should be of the same type.)
Enter the bearing of the radial.	Bearing of radial, if more than one radial is used then these bearings should be the actual true bearings.

2.4 Program REV and NREV

Program REV calculates the single bearing reverberation versus time while program NREV calculates multiple bearing reverberation versus time for the receiver bearings in the input ARRGRD files. REV and NREV use either polar geometry (for monostatic geometry) or bipolar geometry (for bistatic geometry). The major difference is that REV uses the bipolar integration scheme found in Bartberger (1991) while NREV uses a pie slice approach to reverberant area calculation. The output of this program is in micro-Pascals squared relative to a 1-watt source; conversion to decibels requires taking 10 times the log base 10 of the reverberation level and adding the source level in decibels.

Table 4. List of inputs to programs REV and NREV and summary explanation.

Enter the source-receiver separation in units of delta range and the source to receiver bearing in degrees.	* The separation is an integer multiple of the incremental range used in ARRGRD. The source to receiver bearing is the actual bearing in bistatic range-dependent cases.
Enter the name of the input gridded receiver file.	* Output file from ARRGRD for receiver to scattering patches.
Enter the name of the input gridded source file.	* Output file from ARRGRD for source to scattering patches.
Enter the name of the output file.	* ASCII file with maximum of 30 characters.
Enter the wind speed (knots).	a Model uses wind speed for surface scattering coefficients.
Enter column scattering strength (decibels per square meter).	b Column scattering strength for volume scattering.

Enter the scattering strength values (decibels per square meter). Enter value for 0° grazing angle.	c Model uses modified Lambert-McKenzie scattering model, the 0° grazing angle value is minimum allowed value.
Enter value for 90° grazing angle.	c Maximum allowed value (typically -27 decibels).
Enter the initial, incremental, and final times to calculate reverberation (in sec).	* All times are in seconds. Maximum number of time steps allowed is 10001.
Enter the pulse duration (in sec).	* Either the actual pulse length (cw) or the equivalent pulse length.

Notes: * denotes a required input, a refers to inputs that are required for surface reverberation , b refers to inputs that are required for volume reverberation , and c refers to inputs that are required for bottom reverberation.

2.5 Program TGT

Program TGT calculates the target echo level versus time for the receiver bearings in the input ARRGRD files. TGT exists in only one form the pie slice geometry for bistatic predictions. This program does not predict echo level as a function of range or as a function of time. Rather for each range cell (or integration area) the envelope of the target echo time series is calculated, with the maximum level and the time it occurs stored for that location. As with programs REV and NREV the output is in micro-Pascals squared relative to a 1 watt source, not in decibels.

Table 5. Lists of inputs to program TGT, and summary explanation.

Enter the source-receiver separation in units of delta range and the source to receiver bearing in degrees.	* The separation is an integer multiple of the incremental range used in ARRGRD. The source to receiver bearing is the actual bearing in bistatic range-dependent cases.
Enter the name of the input gridded receiver file.	* Output file from ARRGRD for receiver to the target.
Enter the name of the input gridded source file.	* Output file from ARRGRD for source to scattering patches.
Enter the name of the output file.	* ASCII file with maximum of 30 characters.
Enter the target strength (decibels).	
Enter the initial, incremental, and final times to calculate target echo level (in sec).	* All times are in seconds. Maximum number of time steps allowed is 10001.
Enter the pulse duration (in sec).	* Either the actual pulse length (cw) or the equivalent pulse length.

3.0 PROGRAM EXECUTION

In this section the execution of the ADAM model will be described. Figure 1 illustrates schematically the order in which the individual programs are executed.

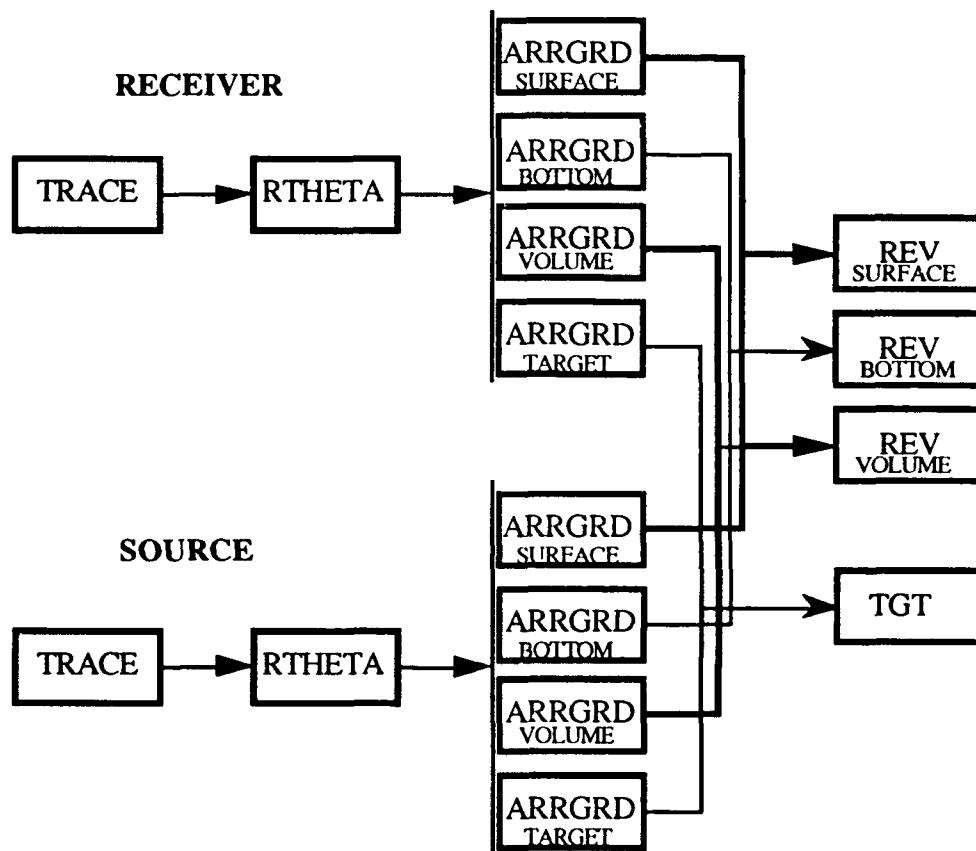


Figure 1. Schematic diagram of the execution of the ADAM model.

A ray trace is made from the source and receiver depths to some maximum range storing the boundary interaction statistics. Along the propagation path, up to 2 depths (one called target, and the other volume) may be selected at which ray-crossing statistics will be stored. The boundary interaction and depth crossing statistics are then used to estimate the transmission loss on a ray family by ray family basis. The arrival structure from the prior process is then

gridded onto a user specified grid for each of the ray family transmission loss files. Then, these files are used to generate reverberation (boundary and volume) and target echo levels.

The discussion of the execution of the model will consider the following cases:

- (1) monostatic single radial
- (2) monostatic multiple radial
- (3) bistatic single radial (range independent)
- (4) bistatic multiple radial (range independent)
- (5) bistatic multiple radial (range dependent).

For each of the five cases, the run stream procedures will be discussed relative to figure 1. In discussing the cases, bear in mind that there are two types of inputs that are required to execute the model. The first type of input is the environmental input. Environmental inputs include the sound speed profile, the bathymetric data along a track, the specification of bottom loss, scattering strengths, and wind speed. The second type of input is the "system" specific input. This second type of input includes the geometry of the problem to modeled, frequency, pulse length, type of source signal, etc. In this section, the discussion will be on how the second type of input affects the run stream. The user is assumed to be cognizant of the necessary environmental inputs. An alternative approach to the bistatic range dependent and monostatic multiradial cases using the GETPROF program is discussed in Appendix C.

3.1 The Algorithm

The general case algorithm will now be presented. In it, each of the five cases mentioned earlier will be discussed. The first step in any run is to assemble the environmental and system information that is required. For this discussion, it is assumed that such information is available in an easily reachable form. The general algorithm is

- (1) for each radial run TRACE for the receiver (this may involve multiple runs).
 - (a) If the run is bistatic range dependent, or the source depth does not equal the receiver depth then for each radial run TRACE for the source.
- (2) run RHTETA using the output files from the receiver TRACE run(s).
 - (a) If the source depth does not equal the receiver depth, or if the run is

bistatic range dependent, or the source characteristics are different from the receiver characteristics then run RTHETA using the output files from the source TRACE run(s).

- (3) run ARGRD for each of the types of output from the receiver RTHETA runs; that is, run ARGRD once using all the surface files (for a single radial case there will be a single surface file), all the bottom files, all the target files, and all the volume files.
 - (a) If a single TRACE, and single RTHETA has been made (that is, range independent with source and receiver collocated of identical system characteristics) then make copies of the output of ARGRD on to unique file names. No other ARGRD runs are needed.
 - (b) Otherwise, run ARGRD for each of the types of the source RTHETA runs (exactly as done with the receiver RTHETA files).
- (4) run REV if the run is not range dependent bistatic, or NREV if the run is range dependent bistatic. Run the reverberation model for each case of interest, surface, bottom, or volume.
- (5) run TGT for the target echo level.

Note that all five cases can be fit into a single algorithm. This is because the only differences between the various cases revolves around whether the source and receiver are collocated if the source has the same characteristics as the receiver, or if range dependency is required in a bistatic case.

3.2 A Simple Example

A simple example of the implementation of the algorithm will now be given for the case of a range-independent bistatic run, where the source and receiver are separated in depth only. This example assumes the following acoustic inputs:

source depth	10 m
source type	omnidirectional
receiver depth	10 m
receiver type	omnidirectional

pulse length	1.25 ms
frequency	1133 Hz
water depth	23 m
sound speed	1485 m/s (assumed isovelocity)
source-receiver separation	150 m
bottom loss	see Table 6

Table 6. Bottom loss for example, where the angles are in degrees, and the bottom losses are in decibels per bounce.

0°	0.00	8°	0.46	16°	0.22
1°	0.45	9°	0.45	17°	2.29
2°	0.88	10°	0.35	18°	3.21
3°	0.64	11°	0.25	19°	2.79
4°	0.68	12°	0.37	20°	3.89
5°	0.84	13°	0.40	21°	7.43
6°	0.50	14°	0.25	25°	13.83
7°	0.49	15°	0.20	90°	13.83

The acoustic inputs and bottom loss listed in Table 6 will be used to generate a run stream for ADAM. An input stream for each of the component models will be listed. For each case, appropriate inputs will be annotated following the semicolon. If this test case is used, then do not include the section to the right of and including the semicolon.

Since the source depth and the receiver depth are identical and the bottom is considered flat, only a single TRACE execution is required. The input stream for TRACE is

```

1      0      0
nor.bth          ; bathymetry input file
0                  ; range in units of kilometers
0                  ; depth in units of meters
nor.svp          ; sound speed input file
0                  ; depth in units of meters
0                  ; units of speed is meters per second
2                  ; use bottom loss from table

```

1133	; frequency in hertz
nor.los	; bottom loss table
10.00	; sensor depth
0	; in unit of meters
0.0	; target depth (indicates no target)
0	
0.0	; volume depth (indicates not in use)
0	
5	; wind speed
1	; in units of knots
3	; maximum range of ray trace
0	; in units of kilometers
a0000s.dat	; name of surface hit file
a0000b.dat	; name of bottom hit file

In the run stream for TRACE, the content of the files nor.svp, nor.bth, and nor.los could be deduced using the information contained in Appendix A. However, each of these files will be described briefly. The bathymetry file nor.bth consists of two pairs of numbers:

0. 23. 5. 23.

indicating that the water column depth is 23 m. The sound speed file nor.svp consists of two pairs of numbers:

0.0 1485
23.0 1485

indicating that the speed of sound is considered constant in the water column. The bottom-loss file nor.los consists of the data contained in Table 6. The format for nor.los is the number of grazing angle, bottom-loss pairs, followed by that number of grazing angle bottom-loss pairs in order of strictly increasing grazing angle.

Since the source and receiver are identical, both omnidirectional, only a single execution of the program RTHETA is required. The output files from TRACE for the bottom and surface

represent both the source and receiver paths; thus, the output files from RTHETA represent both the source and the receiver paths. The input stream for RHTETA is

```
2      0
1133  1      ; frequency and number of elements
a0000b.dat    ; input bottom file from TRACE
r0000b.dat    ; output bottom file
a0000s.dat    ; input surface file from TRACE
r0000s.dat    ; output surface file
```

The output from RTHETA will not be used to generate the gridded arrival structures for the surface and bottom. Since the source and receiver files are identical (and only one has been calculated), only a single ARRGRD for each boundary is required. A description of the input stream for each boundary is presented.

The input stream for ARRGRD for the surface is

```
1      0      0
0.009 1.80    ; incremental and maximum range (in kilometers)
16
gsur.dat      ; output gridded surface file
r0000s.dat    ; input surface file from RTHETA
```

The input stream for ARRGRD for the bottom is

```
1      0      0
0.009 1.80    ; incremental and maximum range (in kilometers)
16
gbot.dat      ; output gridded bottom file
r0000b.dat    ; input bottom file from RTHETA
```

The input stream for bottom reverberation using REV, where hbot.dat is identical to gbot.dat is

```
167    0      ; separation in multiples of incremental range
gbot.dat    ; input gridded bottom file from ARRGRD
```

hbot.dat	; input gridded bottom file (duplicate of gbot.dat)
revbot.dat	; output bottom reverberation file
-44	; scattering strength at 90° grazing angle
-27	; scattering strength at 0° grazing angle
0. 0.001 1.80	; minimum, incremental, and maximum times (seconds)
0.00125	; pulse length (seconds)

The input stream for surface reverberation using REV, where hsur.dat is identical to gsur.dat, is

167 0	; separation in multiples of incremental range
gsur.dat	; input gridded surface file from ARGRD
hsur.dat	; input gridded bottom file (duplicate of gsur.dat)
revsur.dat	; output surface reverberation file
5	; wind speed (in knots)
0. 0.001 1.80	; minimum, incremental, and maximum times (seconds)
0.00125	; pulse length (seconds)

The creation of this example required only a single ray trace, a single RTHETA, and one ARGRD run for each of the boundaries of interest (the surface and the bottom). The single runs were required since the source and receiver are collocated in depth, are both omnidirectional, and the geometry is assumed range independent. Figure 2 shows the plot of bottom reverberation versus time where an arbitrary 218 dB source level has been used. One peculiarity of the model is its behavior in the last time bin. In this example the level falls by approximately 5 dB in the interval from 1.799 to 1.800 seconds. This behavior will occur for all problems where the reverberation is greater than 0 (in linear space) at the last time steps.

4.0 SUMMARY

The basic concept of ADAM was to develop an engineering capability to predict reverberation at midfrequencies in shallow-water regimes. This manual reflects the engineering nature of the model; the model is a collection of programs that requires effort to execute in an intelligent manner.

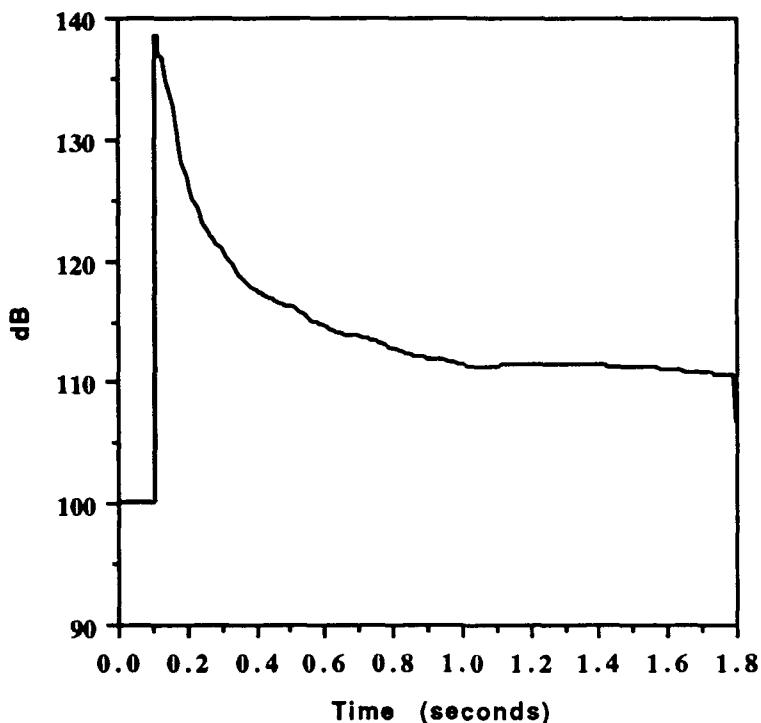


Figure 2. Plot of bottom reverberation versus time for the simple test case.

The inputs of ADAM and the basic concepts of how to execute the model has been described. The model consists of five programs that are executed in sequence to obtain estimates of the reverberation envelope and target echo level for the exercise geometries in question. The inputs for each model have been summarized, and the overall structure of the sun stream has been outlined. The appendices present information regarding input files, a program to calculate transmission loss, and a method of generating run streams.

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APPENDIX A

This section describes three tabular input files that may be required to execute ADAM. Two of the files, bathymetry and sound speed, are required, while bottom-loss files are required if user defined tables are selected by the user. The tabular input file description will follow their order of appearance in the model: bathymetry, sound speed, and bottom loss.

The bathymetry format consists of up to 100 ordered (strictly range increasing) pairs of range depth, where depth is positive downward. An example bathymetric file is given by

0	185
10	180
11	176
13	181
15	168
20	0

where the first column is the range (in units of kilometers, kiloyards, or nautical miles), and the second is depth (in units of meters, feet, yards, or fathoms). The input bathymetry is read to an end of file (eof) mark or until a depth of 0 (or less) is encountered. The model uses a piecewise linear fit to the input data, including the final 0. Thus, for example, the data file example shown assumes a final slope of 33.60 m/km.

The structure of the sound speed file required for GETPROF is described. The ADAM model uses a single sound speed profile; thus, the structure is exceedingly simple. The file consists of up to 47 pairs of depth, sound speed, where the depth is in either feet, meters, yards, or fathoms, and the sound speed is in either feet per second, or meters per second. An example of an input sound speed file is shown below.

0	1525.0
10	1520.8
32	1508.2
47	1508.0
90	1507.9
130	1507.9
200	1508.2

When creating a sound speed field, it is important to have the sound speed field extend below the deepest bathymetric site in the area.

The bottom-loss file consists of two parts, the first part is the number of pairs of grazing angle bottom loss, and the second consists of the ordered pairs (ordered in increasing grazing angle). There may be up to 91 order pairs, although only the bottom loss at 0° grazing angle and 90° grazing angle are required. A sample bottom loss file is shown below:

7	
0	0
5	0
6	1.5
10	3.0
20	5.0
25	4.5
90	4.5

where the first entry is the number of pairs to follow, and the succeeding seven pairs are the grazing angle bottom loss. The algorithms in ADAM take the bottom loss at the specified angles and interpolates linearly bottom-loss values at angles between the specified points.

APPENDIX B

TLVSR (transmission loss versus range) is an integral part of the NRL RASP model. Its purpose is to calculate transmission loss versus range, using the output of the program RTHETA as its input. Due to technical and temporal considerations inherent in creating ADAM, it proved useful to have the output from the modified version of RHTETA used in ADAM to be compatible with the program TLVSR. This section describes the inputs and outputs of TLVSR used with ADAM.

Table 1 lists the inputs in the order that they appear with a summary explanation. TLVSR produces ASCII files, there is no plot capability. This is a design feature. Typical plot capability requires a specific software (or potentially hardware) product for support.

Table 1. Inputs for program TLVSR and summary explanation.

Enter IFPRT, IFARR.	* If IFPRT is greater than 0, then output print file of transmission loss is requested. If IFARR is greater than 0, then output print of vertical arrival structure will be made (If both are 0 the program automatically sets up a print of transmission loss.)
Enter name of input from RTHETA.	* Enter input file created by program RTHETA.
Enter name for output file.	* Valid ASCII name limited to 30 characters.
Enter minimum range (km), incremental range (km), and maximum range (km).	* The limit is 500 range points.
Enter maximum number of arrivals to be found.	a Number of vertical arrivals to be listed for each range bin (limit 48 arrivals).

Note: * denotes a required input, a is required if IFARR is not 0.

The output of TLVSR is an ASCII file. If IFPRT is greater than 0, then a list of range, incoherent transmission loss, and coherent transmission loss is printed. If IFARR is greater than 0, then a list of the vertical arrivals at each range is printed. If both are greater than 0, then the table of transmission losses is printed first, followed by the arrival structure.

APPENDIX C

In this appendix the function of the program GETPROF will be discussed. The inputs will be listed and explained in a brief fashion. GETPROF was originally part of a suite of programs developed at NRL to retrieve environmental information from data bases. In this application it has been modified to set up a series of input files that will allow specific cases that use bathymetric data bases to be run.

The program inputs are listed in Table 1. Three input files needed to execute GETPROF are described immediately following the table. A discussion of the output files generated by GETPROF follow the description of the input files.

Table 1. Listing of inputs necessary to execute GETPROF, and a summary explanation.

Enter the source latitude in decimal degrees.	* The latitude should be entered in decimal minutes with north positive.
Enter the source longitude in decimal degrees.	* The longitude should be entered in decimal minutes with east positive.
Enter the receiver longitude in decimal degrees.	* The latitude should be entered in decimal minutes with north positive.
Enter the receiver longitude in decimal degrees.	* The longitude should be entered in decimal minutes with east positive.
Enter the pulse length (seconds).	* Either the actual pulse length (cw) or the equivalent pulse length.
Enter the incremental time (seconds).	* Incremental time should be less than the pulse length.
Maximum recommended incremental range Enter incremental range (meters).	* The program will give the recommended incremental range (in meters), either use this number or a smaller number.
Enter the number of vertical source elements where 1 is omnidirectional. Greater than 1 implies that many equispaced elements, and less than 1 implies user beam pattern to be entered.	*
Enter the spacing in wavelengths.	a Assumes previous input number of equispaced source elements.
Enter steering direction (- is up).	a Steering direction (positive upwards).
Enter the beam pattern file name.	b ASCII file containing beam pattern (in decibels from -90 to 90 in 1° increments).

Enter the number of vertical receiver elements where 1 is omnidirectional. Greater than 1 implies that many equispaced elements, and less than 1 implies user beam pattern to be entered.	*
Enter the spacing in wavelengths.	a Assumes previous input number of equispaced source elements.
Enter steering direction (- is up).	a Steering direction (positive upwards).
Enter the beam pattern file name.	b ASCII file containing beam pattern (in decibels) from -90 to 90 in 1° increments.
Enter the source depth.	*
Enter the units of source depth: 0 = meters, 1 = feet, 2 = fathoms (Out of range default is meters.)	*
Input the volume reverberation depth.	*
Enter the units of volume reverberation depth: 0 = meters, 1 = feet, 2 = fathoms (Out of range default is meters.)	*
Input the target depth.	*
Enter the units of target depth: 0 = meters, 1 = feet, 2 = fathoms (Out of range default is meters.)	*
Enter the wind speed.	* Wind speed is used for both surface reverberation and surface losses.
Enter the units of wind speed: 0 = meters per second, 1 = knots (Out of range default is meters per second.)	*
Select the source of bottom-loss information: 0 = high frequency bottom loss curves (HFBL) 1 = Fleet numeric bottom loss curves (FNWC) 2 = user provided tabular input Default value (invalid selection) is HFBL.	* HFBL offers the choice of ten provinces. FNWC offers the choice of three provinces. User defined tabular input requires (a) the number of grazing angle bottom-loss pairs (maximum 91) (b) a line consists of grazing angle bottom loss (c) the loss at 0° and 90° be specified.
Enter the frequency for bottom-loss calculation in hertz.	* Frequency is used for both bottom loss and scattering.
Enter the province number (0 through 9).	c HFBL provinces.

Enter the province for FNWC bottom-loss curves. There are three provinces 1, 2, and 3. The out of range value is 1.	d FNWC areas.
Enter bottom-loss file name.	e Bottom loss for user input, as described below.
Enter name of sound speed file name.	*
Enter depth units associated with the sound speed file: 0 = meters, 1 = feet 2 = yards, 3= fathoms (value out of range = kilometers).	*
Enter units associated with the sound speed file: 0 = meters per second 1 = feet per second (value out of range = meters).	*
Enter name of bathymetric file name.	* Bathymetric file consists of a gridded data base (described below).
Enter depth units associated with the bathymetric file: 0 = meters, 1 = feet, 2 = yards, 3 = fathoms (value out of range = meters).	*
Enter name of file containing bearings.	* Bearing file name limited to 30 characters (file described below).
Enter increment for track data.	* Increment in units of nautical miles.
Enter the receiver depth.	*
Enter the units of receiver depth: 0 = meters, 1 = feet, 2 = fathoms (Out of range default is meters.)	*
Enter column scattering strength (decibels per square meter).	f Column scattering strength required if volume reverberation depth is greater than 0.
Enter target strength (decibels).	g Target strength (omnidirectional) required if target depth is greater than 0.
Enter bottom scattering strength value at 0° grazing angle.	* Model uses modified Lambert-Mckenzie scattering model, the 0° value is the minimum allowed
Enter bottom scattering strength value at 90° grazing angle.	* Maximum value allowed (typically -27 decibels).
Enter the initial and final times for reverberation calculation.	* There can be no more than 10001 times; thus, final time - initial time divided by incremental time can be no greater than 10000.

Notes: * denotes a required input, **a** optional only needed when number of vertical phones is greater than 1, **b** optional only need when number of vertical phones is less than or equal to 0, **c** refers to inputs if HFBL is requested, **d** refers to inputs if FNWC is requested, **e** refers to

inputs required if input bottom-loss table is requested, f optional needed if volume reverberation depth is greater than 0, and g optional needed if target depth is greater than 0.

Input Files

In this section three input files required by program GETPROF will be described. They are the sound speed file, the bathymetry file, and the bearing file.

The structure of the sound speed file required for GETPROF is described. The ADAM model uses a single sound speed profile; thus, the structure is exceedingly simple. The file consists of up to 47 pairs of depth, sound speed, where the depth is in either feet, meters, yards, or fathoms, and the sound speed is in either feet per second or meters per second. An example of an input sound speed file is shown below.

0	1525.0
10	1520.8
32	1508.2
47	1508.0
90	1507.9
130	1507.9
200	1508.2

When creating a sound speed field, it is important to have the sound speed field extend below the deepest bathymetric site in the area.

The structure of the bathymetric data base required for GETPROF is described. The structure is based on chart file format; it has however been modified for the purposes of this program.

The data base consists of two essential parts. The first part is the header, the second is the actual data. The header consists of

- longitude (west most)
- longitude (east most)
- latitude (south most)
- latitude(north most)
- increment in minutes between points

number of longitude values

number of latitude values.

The header is followed by the number of longitude values multiplied by the number of latitude values of the triplet longitude, latitude, depth. The order of the data is constant latitude from western most point to eastern most point.

A simple example of such a data base follows.

-65.00	-64.00	18.00	19.00	20	4	4
-65.00		18.00	200.			
-64.67		18.00	200.			
-64.33		18.00	200.			
-64.00		18.00	200.			
-65.00		18.33	175.			
-64.67		18.33	175.			
-64.33		18.33	175.			
-64.00		18.33	175.			
-65.00		18.67	150.			
-64.67		18.67	150.			
-64.33		18.67	150.			
-64.00		18.67	150.			
-65.00		19.00	125.			
-64.67		19.00	125.			
-64.33		19.00	125.			
-64.00		19.00	125.			

This example illustrates a plane sloping upwards to the north going from 200 depths units in the south to 125 depth units in the north.

The bearing file required has a single format. It consists of a list of the bearings in decimal format. The list of bearings must be in order from minimum (that is, nearest to 0) to maximum. A simple bearing file is

86

120

200

254

289

313

You are limited to 30 bearings. While there is no restriction imposed on the choice of bearings, it is recommended that a typical file should consist of good general coverage (that is, a coarse equiangular grid) with specific bearings densely covered. A note to the user (of some importance), the names of the intermediate files will reflect the bearings that are used to generate great circle path radials; thus, take care in not duplicating file names by creating each run in a separate subdirectory.

Output Files

The output of GETPROF consists of 10 files. The files are

souray.inp	input file stream for the source ray trace
recray.inp	input file stream for the receiver ray trace
sourth.inp	input file stream for the source RTHETA run
recrth.inp	input file stream for the receiver RTHETA run
arsosu.inp	input file stream for source to surface arrival grid run
arsobt.inp	input file stream for source to bottom arrival grid run
arsotg.inp	input file stream for source to target arrival grid run
arsovo.inp	input file stream for source to volume depth arrival grid run
arresu.inp	input file stream for receiver to surface arrival grid run
arrebt.inp	input file stream for receiver to bottom arrival grid run
arretg.inp	input file stream for receiver to target arrival grid run
arrevo.inp	input file stream for receiver to volume depth arrival grid run
revsur.inp	input file stream for surface reverberation run
revbot.inp	input file stream for bottom reverberation run
revvol.inp	input file stream for volume reverberation run
target.inp	input file stream for target echo run.

Each of these input files are ASCII thus, human readable. They are in fact, identical to the inputs that would be entered at the keyboard to run the program interactively. Due to variability of system setups, no attempt has been made to create a batch file routine. However, with the addition of set defaults and other system specific commands, they can be transformed into batch files. For example, on a UNIX system, the TRACE program can be executed using this source ray trace input stream:

```
mysun/adam/trace < souray.inp
```

where mysun/adam is the location of the ADAM executables and TRACE is the name of the executable ray-tracing program.

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